On the Green Colour of the Hair of Sloths. By H. C. Sorby, LL.D., F.R.S., F.L.S., V.P.G.S.

[Read April 7, 1881.]

Some years ago the late Mr. E. R. Alston called my attention to the green colour of the hair of *Bradypus castaniceps*, noticed by Seemann, who had inquired of Dr. J. E. Gray whether he knew any green species of Sloth, for that such was the colour of one living in Nicaragua. Seemann, in a letter quoted by Gray in a paper in the 'Proceedings of the Zoological Society'*, raised the question whether this green tint, so abnormal in mammals, might not be due to a parasitic alga; and suggested that one reason why the animal was so seldom seen was that the coarse hair, thus coloured, made the creature look almost exactly like a mass of the so-called vegetable horsehair (*Tillandsia usneoides*), so common on the trees of the district where the Sloth occurs. Little or no further attention appears to have been directed to this question in England; and neither Mr. Alston or myself had any idea that it had been carefully studied in Germany. On examining, both microscopically and spectroscopically, some of the hair from Seemann's specimen, which had retained its colour where not exposed to the light, and comparing it with specimens from *Cholopus Hoffmanni*, I was soon convinced that Seemann's explanation was correct; and after I had devoted a considerable amount of time to this subject, Mr. Alston accidentally found that Welcker and Kühn had published a very complete memoir on the growth and structure of the hair of Sloths and on the algæ parasitic on them†. I cannot therefore lay claim to having been the first discoverer of these organisms, but have worked out the question in an independent and different manner, and observed some facts which are not described in the paper just cited.

In the first place, I have had the advantage of studying fresh material, and not, like previous authors, merely specimens that had been kept long in museums, which was perhaps the reason why the general green colour of the hair is not alluded to by Welcker and Kühn. Early in the year 1877 a *Cholopus* was sent to the Zoological Society's Gardens direct from its habitat, which died very soon after its arrival; and Mr. Bartlett kindly placed

* 1871, p. 429.

† Abhand. der naturf. Ges. zu Halle, 1866, vol. ix. p. 20.

the entire skin at my disposal. I have also had the advantage of studying the hair of specimens which had lived some years in England; and was thus able to learn that none of the green algæ grew on the hair in the dry atmosphere of the house in the Gardens, whereas on that of the animal fresh from its native damp woods the number on the hair from some parts of the skin was so great as to give rise to a most unmistakable green colour, not seen in the case of the animals which have lived some time in this country. It therefore appears that the growth of the alga depends partly on the damp character of the locality in which the Sloths live. I, however, think that it also depends, in great measure, on the most exceptional and remarkable structure of the hair of Sloths; and after having carefully studied that of very many other animals, I must say that it appears to me not at all probable that algæ would grow on the hair of other mammals, even in damp localities.

For my present purpose it is convenient to look upon hair as a very variable mixture of dense horn and a highly cellular pithy substance, containing much air. As an example of one extreme, I may refer to the bristles of the wild boar, which are generally almost exclusively composed of dense horn. In many animals the hair consists of a solid external sheath of horn, with a central pithy core, the relative size of which varies much; and in the case of nearly all Deer and some Antelopes and allied animals this central pith constitutes nearly the whole, and the external horny layer is very thin. In all these cases this layer is continuous over the whole exterior; and though sometimes the surface is rough and scaly, yet in many cases it is almost or quite smooth and glossy.

The hair of *Cholopus* (figs. 4 & 5) differs in a most remarkable manner from all others that I have examined. Instead of the horny exterior being continuous, it is more or less deeply fluted longitudinally, right down to the central pith, which is thus exposed along the bottom of the numerous grooves (fig. 4). The growth of the green algæ is most unmistakably related to this structure. None grow on the surface of the bright glossy ribs, whereas all along the depressions they abound, so that we see clear polished ribs and deep green hollows extending longitudinally along each hair (fig. 5). I do not see how we can doubt that this special localization is due to the fact that the surface of the grooves is rougher, as well as more protected from friction, than the ribs.

Probably this influence of friction is the reason why the general green colour of the hair is so much better marked in some parts of the animal than in others, being more especially visible at the back of the head and neck.

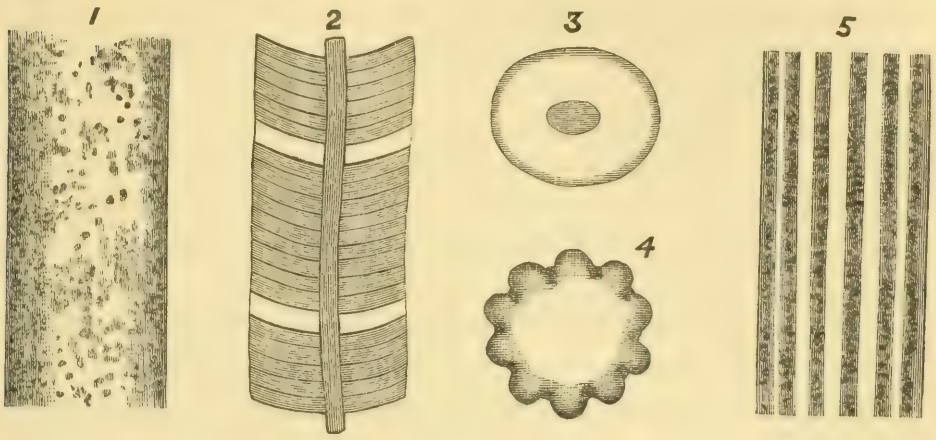

Fig. 1. Hair of *Bradypus* with algæ on surface.
2. The same, old and cracked.
3. The same, transverse section.
4. Hair of *Cholopus*, transverse section.
5. The same, surface with algæ in hollows.

The structure of the hair of *Bradypus* (figs. 1, 2, & 3) differs as much from that of *Cholopus* as from that of all other animals* which have come under my observation; and in fact we might almost say that it is the reverse of the normal. Instead of there being a horny sheath and a central cellular pith, there is a central horny thread (fig. 3) and a pithy exterior, with somewhat oblique transverse structure, made much more transparent when saturated with Canada balsam. The result of this remarkable structure is that old hairs break up into numerous segments (fig. 2), which look like angular beads strung on a central horny thread, so as to make the hair, roughly speaking, somewhat like the barbs of certain feathers with attached barbules. It is on this external pithy portion of the hair that the green algæ grow (fig. 1); and I am disposed to believe that they are able to grow on it mainly because the surface is sufficiently rough to allow them to attach themselves so firmly that they are not easily removed by friction.

It will thus be seen that I attribute the presence of the algæ

[* There is a small Sloth, however, in which the larger hairs are quite smooth and solid.—Ed.]

on Sloth's hair quite as much to its exceptional structure as to the humidity of their habitat, and look upon this unusual growth of green parasitic plants as due to the combination of both conditions*. If the green colour is really a protection to the animal, one cannot help asking whether the structure of the hair is connected with this protection, either by design or by gradual development.

On examining the hairs in a natural state with the microscope every stage in the growth of the small green algæ can be seen; but many facts may be better observed by heating the hair in dilute caustic potash. This dissolves the horny substance of the hair, but leaves the algæ more or less free. There is then no difficulty in studying every phase of growth, from green specks of $\frac{1}{10,000}$ inch in diameter up to cells of $\frac{1}{2000}$ diameter; and they are seen dividing and subdividing in much the same manner as the cells of *Chlorococcum*, so common on damp walls and trees. Kühn describes those met with on the hair of *Bradypus* as differing from those on *Cholopus*, basing his conclusion, to a great extent, on the number and form of the spores. He names them respectively *Pleurococcus Bradypi* and *P. Cholœpi*. The plants certainly differ in several particulars; but one may doubt whether the difference is not due to difference of conditions. One grows on a comparatively flat surface, which allows of lateral extension; whereas the other grows in grooves, which allow of only free linear development. We cannot say whether the spores of the one form would grow into the other under changed conditions; but, at the same time, the different conditions may have led to the production of well-marked hereditary peculiarities. However, whether we call them species or varieties, at all events there can be no doubt that they are minute parasitic plants; but at the same time I thought it desirable to confirm this conclusion by the independent evidence of spectroscopic examination.

On heating in alcohol the hair of the *Cholopus* fresh from America, the colour was not dissolved, but it was readily soluble after the hair had been boiled in water, and yielded a fine green solution. This I studied very carefully, separating the different constituents in the manner described in my paper on comparative vegetable chromatology†, and compared it with the solution

[* The hair of Bats, it may be observed, seems adapted for a growth of algæ, so far as mere structure is concerned.—Ed.]

† Proceedings of Royal Society, 1873, xxi. p. 442.

obtained in a similar manner from *Chlorococcum*. Both contain the six different-coloured substances usually, if not invariably, met with in green algæ and in plants of higher organization, but in different relative proportion. The most striking fact was, that the variety of chlorophyll which I have named "yellow chlorophyll," characterized by a spectrum very different from that of the more abundant "blue chlorophyll," exists in a much larger relative amount than in plants of high organization, and even in larger amount than in other green algæ which I have examined, but perhaps not in larger than might very well occur in minute green algæ growing in damp tropical woods. On the contrary, what I have called "orange xanthophyll" occurs in smaller amount in the algæ from the hair than in *Chlorococcum*. I subjoin comparative analyses, which must be looked upon as only approximate. They, however, suffice to show most clearly that the green colour of the hair of Sloths is due to the presence of precisely the same colouring-matters as those found in green algæ, the difference being no greater than what may be due to small differences in conditions.

	Chlorococcum.	Sloth's hair.
Blue chlorophyll	48	53
Yellow „	10	17
Xanthophyll.....	16	17
Yellow xanthophyll.....	16	8
Orange „	6	1
Lichnoxanthine	4	4
	100	100

Descriptive Catalogue of the Species of *Cellepora* collected on the 'Challenger' Expedition. By George Busk, F.R.S., F.L.S.

[Published by permission of the Lords Commissioners of the Treasury.]

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The number of species here referred to the genus *Cellepora* is about 26 or 27.

Of these—

1. The *North-Atlantic* region yielded three, from depths varying from 51 to 450 fathoms.